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HUMAN ENGINEERING

AN INTERVIEW WITH JOHNSON O'CONNOR

THAT graduates of academic schools seem in general to be more fitted for executive work than are graduates of technical schools is indicated by the results of a series of tests conducted by Mr. Johnson O'Connor. All major executives who have taken his vocabulary test have ranked 130 or above. Seniors at Harvard and at other academic colleges where the tests have been given rank about 129. At the Massachusetts Institute of Technology several years ago the senior average stood at about 129 but has lately declined to 121. At Steven Institute of Technology where, as the result of the tests much attention has been given to vocabulary and the consequent training in analysis, the senior average has been brought up approximately to 129. The indication, although not very pronounced, is that technical schools graduate men more fitted for research, science, and purely engineering work.

The tests used by Mr. O'Connor, himself a trained engineer, are the result of scientific methods of research and experimentation applied to the study of natural aptitudes in human beings. Some eight years ago, Mr. Johnson O'Connor, applying his engineering, began devising a set of tests which should serve to differentiate men with engineering ability from men with no special fitness for engineering. A test was made up and tried on well-known successful engineers. They did it poorly, and as a result the test was judged unsatisfactory. Another was tried with the same result, and still another, until some twenty-five had been tried and discarded. Finally, a test was found which 85 per cent of the successful engineers did well, whereas men in general did it poorly. This was the so-called wiggly-block test, which employs a block of wood cut into three irregular pieces vertically and recut irregularly horizontally. The test determines how quickly an individual can fit the nine pieces together, speed indicating the power to visualize structure and to think in three dimensions.

To make sure that the test actually tested natural engineering ability and not the result of training which anyone could acquire, it was tried on approximately one thousand boys who had had no engineering training. They were graded A, B, C, and D, according to whether they did it relatively well or poorly. The success of these boys in engineering has been watched ever since. Of group A, about seventy per cent are now engineers, of group B about thirty per cent, of group C about ten per cent, and of group D only two per cent. This test has been tried on enough groups since then to indicate that the percentages are substantially correct for men in general and that the test actually measures engineering aptitude quite correctly.

Since beginning the tests, Mr. O'Connor has devised a number of others intended to indicate such various aptitudes as clerical, mechanical, imaginative, finger dexterity, musical, and others. Used in groups, these which show fitness for such diverse occupations as executive direction, banking, architecture, science, research, secretarial work, and many others. Some of the tests are general and cover several aptitudes but when used in conjunction with others denote a special aptitude or lack of it.

One test for clerical aptitude which applies to banking, auditing, or allied subjects consists of a rapid comparison of a series of numbers, the accuracy and speed with which the test is performed indicating the degree to which the subject possesses that aptitude. Another test shows whether a person has an objective mind suited to business or executive work, or a subjective mind suited to engineering, research, and science.

A very important test for executive ability is the vocabulary test. It has been found that all major executives possess an extraordinarily wide vocabulary, showing that they have the ability to differentiate exact shades of meaning between words and to analyze clearly and correctly not only their reading but any problems which they are called upon to solve.

Some interesting results have come from the application of these tests. It has been found, for instance, that the man who is quick at any particular test tends also to be accurate, whereas the slow man is more apt to make mistakes. The "slow-but-sure" person is very much the exception rather than the rule. Another observation is that the brilliant and gifted young man who is able to do exceptionally well on all the tests is very apt to jump from one thing to another without concentrating on anything, with the result that he may fail at all of them. On the other hand, the less universally gifted person who gets good results at one test but makes only an average showing on the rest tends to work hard on his one particular specialty and to make a success of it.

The above tests and others are now being used at several schools and colleges, laboratories for conducting them having been set up in Boston and New York. The

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OPPORTUNITIES IN RUSSIA?

By
CLARENCE T. STARR

WHEN the Bolsheviki had consolidated their political forces in Russia and proceeded with the management of all industries they made the interesting discovery that engineering brains were quite as essential in the scheme of things as workers' brawn and that in that one essential there was a woeful lack within their own borders.

War and revolution had exacted their toll of a class that never had been very extensive and the "liquidation" of the intelligentsia had about completed the extinction of this much needed material. In 1928 it is doubtful if Russia could muster more than ten per cent of her pre-revolution engineering strength and those in the profession who had survived the ordeal were so dispirited by continuing suspicion and persecution as to be of little practical value.

It is possible that even under these circumstances the Bolsheviki managers could have restored their existing industries to pre-revolution capacities within two years if they had known as much about management as they knew about politics. However, having neither faith nor confidence in their own engineers and having launched forth on a five-year construction program of almost inconceivable proportions the leaders had no alternative but to call on the outside world for technical assistance. Thus began the importation of foreign engineers along with foreign machinery and equipment.

In estimating the opportunities this situation presented to American engineers some writers concluded it was nothing more than an attempt to get engineers into the country and convert them to communism, others even less familiar with the facts suggested it was just another impertinent communistic gesture intended to secure the sympathetic support of the profession in the attempt to obtain foreign credits.

It is admittedly an interesting phenomenon to find communist leaders admitting a weakness and appealing to the capitalistic nations for the help needed to build up the machine with which they expect to overwhelm the world.

But in the writer's opinion it is a serious mistake to evaluate opportunities in Russia on the basis of motives and in this connection recalls a remark made by a Russian engineer during a discussion we were having on the motives behind a sudden and startling change in policy. He said, "You can never be sure of anything in Russia except the fact that it is wet when it rains."

The longer the writer remained in Russia the more he appreciated the wisdom of this friendly advice; therefore, in attempting to answer the query actuating this article we will forget motives and examine conditions.

As indicated above, the leaders were compelled to call in outside help and in following the dictates of necessity they were not establishing a new precedent, for Russia always had depended on some outside agency for her industrialization. In the years preceding the revolution, Germany had been the principal source of contact. Not only had her engineers designed and built the factories, mines, and other industrial plants but they had also supplied the machinery, capital, and many executives.

Our principal interest lies not so much in the fact that the Soviets went outside for help but that they came to America for it.

The first concrete evidence we had of this situation was when Russia discontinued the practice of purchasing our machinery through German agents, set up her own purchasing department in New York (Amtorg) and began sending commissions to the United States to investigate our industrial systems, engineering methods, schools, and colleges.

The work of these commissions was thorough and painstaking and resulted in the employment of several thousand American engineers. Every branch of our profession is now represented in Russia by one or more members. Some are employed under individual contracts and others form parts of an organized group taken over by some consulting firm.

Every engineer chosen for this work has been selected on the basis of his experience, outstanding ability in his own line of work, and technical training, with emphasis on the first of these qualifications. A survey would probably disclose that few Americans in Russia have had less than eight years practical experience and the majority have had more than ten years.

With but few exceptions, the engineer who accepts a place in Russia arrives at his destination with the satisfied feeling that he can fill the bill, produce the goods, improve his own knowledge and thus assure for himself a wonderful future, a perfectly natural attitude for any ambitious engineer, but unfortunately in Russia under a system which considers self-interest a crime, this attitude ceases to be a virtue and becomes nothing more than a contributing cause to the engineer's bewilderment.

This bewilderment does not originate from this one cause alone nor does it occur suddenly; it is a gradual growth which settles down on the American engineer when he begins to find himself enmeshed in a labyrinth of formulae, rules and regulations prescribed for this and that; when after days and nights of careful planning he is advised that owing to a change in plans his carefully thought out scheme must be discarded; or perhaps because of a shortage of material a building of a different design must be developed.

It is not an uncommon experience for the engineer to discover on arrival at his office in the morning that over night a complete change has occurred in the organization with which he has been working. A new director has been appointed, a chief engineer with entirely different ideas from the old may be in charge, a new plan of procedure has been developed and many of his working companions have disappeared.

Under the system prevailing today, authority and responsibility are divided, authority resting with the political group, responsibility on the helpless engineer. Under such a system, at complete variance with every concept of good management and organization, how can the American engineer be efficient? What opportunity does he have for independent expression? Of what value is his experience when he must subscribe to formulae based as much on expediency as mathematical logic and must submit to the constant criticism of embryonic engineers or the whim of an impractical professor with a pet theory?

These and other factors such as changed living conditions, being compelled to live in an atmosphere of distrust which envelops everything and everybody, constantly observing the acute discomfort of his Russian neighbors, are certainly not conducive to happiness or an incentive to enthusiastic endeavor. But in the writer's opinion the greatest obstacle to the progress and success of the American engineer in Russia is his inability to adjust himself to a system which smothers individual initiative or effort. Because of these conditions many able engineers have declined to renew their contracts and it is my conviction but a small proportion of the men would remain in Russia if jobs were available in the United States.

No, my idea of an opportunity for the young American engineer does not include a job in Russia and as for a future, what future can there be in a country that arrests and shoots its engineers if they make a mistake, changes plans at the whim of some political committee, places political allegiance above merit and considers self-interest, the most fundamental instinct of the human being, a crime?

Photographs from "U.S.S.R. in Construction"

Present-day Russian laborers. Miners ready to enter the new mines opened up under the Five-Year Plan.

When asked what he considered to be the possibilities of a future for young American engineers in Russia, Colonel Starr responded with the article presented herewith. He has lived in Russia three years as manager for a firm of American consulting engineers having contracts with the Soviet Government.

In the course of his regular routine work he was continually in touch with leaders, technical staffs, officials, and workers of the Russian operating companies or trusts. He also had frequent conversation with the members of the Supreme Economic Council at Moscow.

Through his wide contacts he was able to observe not only conditions in Russia but the position of foreign engineers called in to help in the operation of the so-called Five-Year Plan. He is therefore well qualified to write on "Opportunities in Russia."

RECENT USES OF CATALYSIS

By Professor H. W. Underwood, Jr.
Department of Chemistry, Massachusetts Institute of Technology

A catalyst is usually defined as a substance which changes the rate of a chemical reaction, either positively or negatively, or initiates a reaction and which remains unchanged in chemical composition at the completion of the process. Often the physical state of a catalyst is altered by use. A small amount of a catalyst will transform large quantities of other materials. The use of catalysts is necessary in many important industrial processes, such as the fixation of atmospheric nitrogen, the hydrogenation or "hardening" of fats and vegetable oils, the manufacture of sulphuric acid, the production of nitric acid from ammonia, the vulcanization of rubber, the preparation of ether from alcohol, and many others. This paper gives a brief account of some representative, recent industrial applications of catalysts.

A New Synthetic Rubber

Several weeks ago it was announced that a plant is being constructed for the manufacture of a new synthetic rubber called "duprene." This substance is prepared from acetylene, and all of the raw materials required are available in almost unlimited quantities. The production of this new rubber is a matter of great scientific and industrial interest. It is not expected that "duprene" will replace natural rubber for the manufacture of automobile tires, but it is believed that many commercial uses will be found for the synthetic material on account of its unique properties.

Synthetic rubber constitutes one of the most interesting chapters in the history of man's efforts to duplicate the products of nature. More than a century ago Michael Faraday determined the composition of caoutchouc, the hydrocarbon-polymer in rubber. In 1860 Grenville Williams obtained isoprene by the dry distillation of rubber, and apparently recognized that rubber is a polymer of isoprene. Repeated efforts have been made to synthesize rubber from isoprene, butadiene and dimethyl-butadiene, but no process has yielded a material equal to natural rubber for the production of soft vulcanized articles, and no method has been commercially practicable except as a last resort when the supplies of rubber to certain European countries were cut off during the war.

In the preparation of "duprene" monovinyl-acetylene is first made by the catalytic polymerization of acetylene. The addition of hydrogen chloride to monovinyl-acetylene yields "chloroprene" (2-chloro-1,3-butadiene), and "duprene" is obtained by the controlled polymerization of "chloroprene." "Duprene" is a fully vulcanized, rubber which has properties similar in a general way to products obtained by the vulcanization of natural rubber with sulphur. It is possible to stop the polymerization of "chloroprene" at an intermediate stage, thereby obtaining a plastic substance with the general properties of unvulcanized rubber.

This material may be compounded with fillers, diluents, etc. in the same manner as natural unvulcanized rubber, and the polymerization or vulcanization can then be completed by merely heating the mixture for a short time at a moderate temperature. The polymerization of "chloroprene" occurs very rapidly in aqueous emulsions, and the resulting product constitutes a synthetic vulcanized latex. On account of the small size of the particles, the synthetic latex impregnates many porous materials which cannot be impregnated with natural rubber latex. "Chloroprene" can also be polymerized in the pores of various materials, thereby impregnating them with synthetic rubber. "Duprene" is superior to natural rubber in its resistance to water absorption and decomposition by ozone, oxygen and chemicals. The synthetic rubber is less strongly swelled by petroleum hydrocarbons and most other solvents than natural rubber.

Hydrogenation of Petroleum and Coal

Until the last few years commercial hydrogenation processes have been restricted to the use of very pure hydrogen at substantially normal pressure or two to three atmospheres, powerful but sensitive catalysts of the reduced nickel type, and temperatures safely below those at which thermal decomposition of the initial material occurred. Coal and oil, which always contain sulphur, were not amenable to this type of hydrogenation, and it was therefore restricted to animal and vegetable fats and oils. Recently the development of robust, sulphur-resistant catalysts and the use of high pressures made it possible to convert coal into gasoline and other oils by treatment with impure hydrogen. A short time ago Bergius was awarded the 1931 Nobel prize for his work in this field and the synthesis of methanol.

The use of this new procedure in the hydrogenation of petroleum has made it possible to obtain high yields of good quality gasoline from crude asphalt oils of all sorts and from refinery residues, without coke or tar formation. The hydrogenation process gives the petroleum industry a means of confining its production of heavy fuel oils to the economic market demand, and a means of balancing crude petroleum production against the demand for refined colorless products, gasoline, Diesel fuels, burning oils, etc., independent of the natural heavy fuel contents of the crude materials.

With the improvements in the internal combustion engine and particularly with the rapid expansion in air transportation, there has developed an insistent demand for better motor lubricants. The hydrogenation process makes it possible to obtain high quality lubricating oils from a wide variety of inferior lubricating distillates. On account of the remarkable facility with which catalytic hydrogenation eliminates all types of sulphur compounds from petroleum products, this process has been used for the preparation of high-grade gasoline from impure, unstable, natural and cracked naphthas. Good anti-knock gasolines can be made from paraffinic gas oils.

On account of the oversupply of crude oil, hydrogenation in its present state of development may be considered as supplementary to present refining methods, but it will probably supplant them when the supply of crude oils and the demand for lighter products approach a balance.

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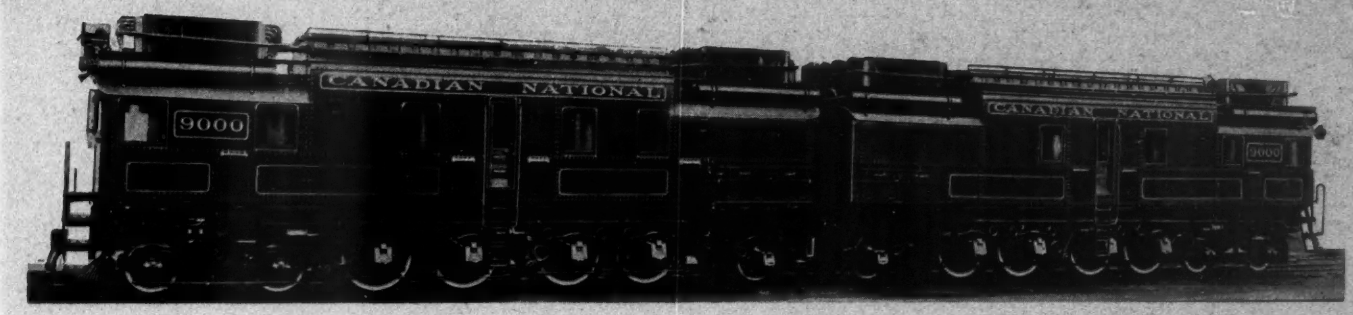

THE ELECTRIC HORSE

By E. Harold Anderson '32

Thirty-six years ago the first electrical train was built as an experiment for short summer runs along Nantasket Beach near Boston. Since then railroad electrification has grown rapidly until now it extends over 4500 miles of track. Electrification was first adapted to steam railroads in 1905 when sixteen miles of the Long Island Railway from Flatbush to Rockaway Park were equipped with third rail carrying 600 volts D. C.

Desire of the roads to free their patrons of the discomforts due to smoke-filled tunnels led them to focus electrification work from 1908 to 1913 almost entirely on tunnels. In these and all other electrifications, it is interesting to note that seldom have more than two or three roads used the same system of distribution of power, a fact which indicates that each project was built in its particular way for one reason as a means of experiment for testing its desirability for use on future large projects. The Butte, Anaconda, and Pacific in 1913 introduced 2400 volts D. C. with overhead catenary supports on 140 miles of track.

Two years later Chicago, Milwaukee, St. Paul, and Pacific laid 650 miles of electrification using 3000 volts D. C. from nearby hydroelectric power. In the same year Norfolk and Western used 11,000 volts single phase from a steam plant located next to coal mines. The sixteen locomotives on this line take power through phase converters. These last two railroads introduced regeneration of power not for the economy of power, but for holding trains on long down grades.

Regeneration of power is one of the major economies of railroad electrification in mountainous regions. When an electric locomotive is coasting down a long grade, instead of taking power from the line, the inertia of the train drives the locomotive motors, which then generate power to put back into the line at the expense of the power gained by the force of gravity, thus supplying more power to locomotives on the up grade. On the two roads just mentioned, however, the motors on the locomotives going down grade use this regeneration of power to brake the train, that is, to cut out some of the power gathered by the train due to its acceleration under gravity, hence slowing down the train just as running an automobile down hill in second gear.

New York Central uses 600 volts D.C. on third rail on about 400 miles of track with 170 electric locomotives of the three power type. The New York, New Haven, and Hartford, one of the largest electrification projects, now operates over 800 miles of track in 11,000 volts single phase with overhead construction. The Virginian, also using 11,000 volts single phase on 230 miles, has probably the greatest concentration of power demand in one single electric train, their three-cab locomotives weighing 1,000,000 pounds apiece. The Long Island Bay Ridge Line has 100 miles of 11,000 volts single phase. In 1927, the Great Northern put in its spectacular electrification project through the Cascades for 93 miles using 11,000 volts single phase, its nine locomotives being equipped with regeneration for electric braking. The Illinois Central uses 1500 volts D.C. over 154 miles of track, its switching locomotives introducing the feature of weight transfer compensation. When pulling their hardest, the trucks tend to "rear back" as the leading wheels transfer some of the load to the rear wheels. This condition causes slipping of the front wheels and cutting off of the tractive effort of the rear wheels as well. To counteract this effect, the front motor fields are manually weakened by shunting, which reduces the tractive effort and increases that of the rear

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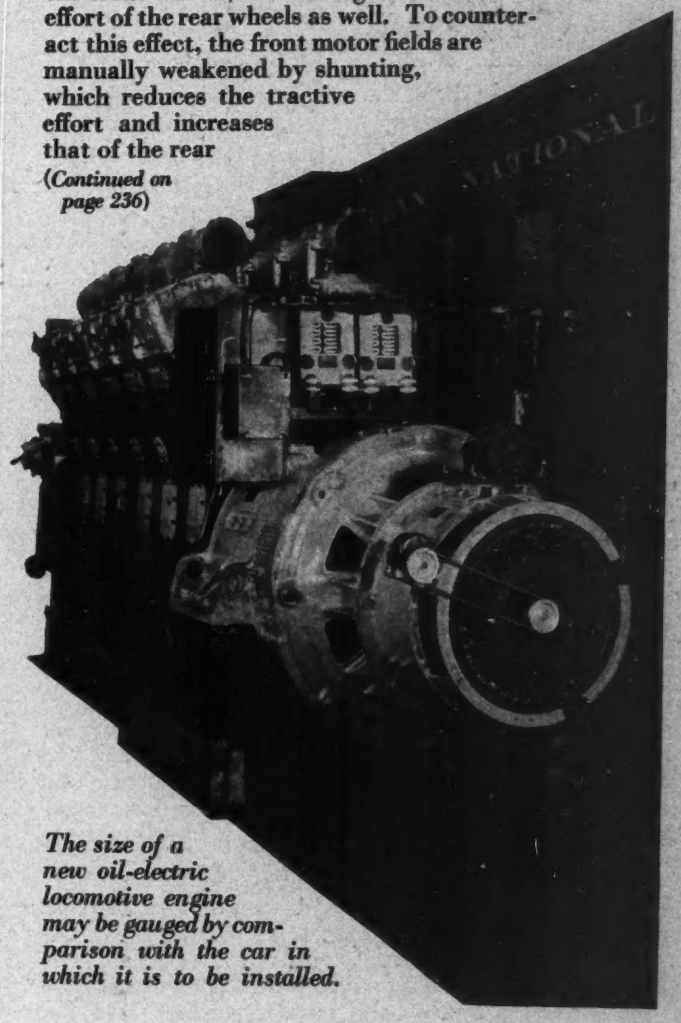


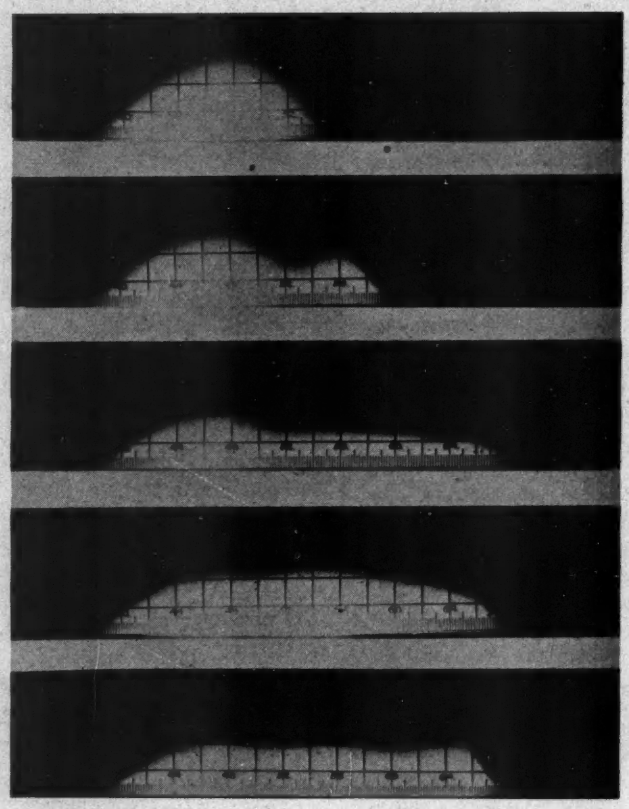
The size of a new oil-electric locomotive engine may be gauged by comparison with the car in which it is to be installed.

COLOR PHOTOGRAPHY

By H. Parker
Kodak Research Laboratories

The action of light in causing a darkening of certain silver salts has been known for many years. It had undoubtedly been observed by the early alchemists, but that the effect is due to light and not to the action of various vapors of the atmosphere was first definitely recorded by Schulze in 1727. Apparently Wedgwood and Davy in 1802 were the first to produce pictures by photographic means. Using paper treated with silver chloride, Davy succeeded in making photographs through a microscope by using sunlight. These pictures were not practically successful, however, because no way was found to remove the unaffected silver compounds, so that on further exposure to light the sheet darkened all over and the picture was lost.

In 1839 the first practical photographic processes were made public. One, the Daguerreotype, which used a thin layer of silver iodide formed on the surface of a silver plate, was immediately successful and was widely used for about ten years, particularly for portrait photography. The other process, invented by Fox Talbot, although not immediately successful, was more important than the Daguerreotype in the subsequent development of photography. Talbot found that pictures made on the silver chloride paper of Davy could be "fixed" or made permanent by dissolving the unaffected silver compounds in a solution of common salt or better, as proposed by Herschel, sodium thiosulfate or "hypo." The most important contribution of Talbot, however, was made two years later when he discovered that a chemical reducing solution known as a developer could be used to transform the invisible latent image produced by short exposure to light into a visible silver image. Since the first exposure produced a negative image which was dark in the light areas of the object and light in the dark areas, Talbot exposed a second sensitive sheet behind this developed negative to obtain a positive print. These processes of development, fixation, and printing are the basic foundation on which modern photography has developed.



Spectograms for various photographic materials. Top, ordinary non-sensitized emulsion; second, orthochromatic emulsion; third, old type panchromatic emulsion; fourth and fifth, newest panchromatic materials. The last two correspond most nearly to the range of the eye.

Immediately after the introduction of the Daguerreotype process, its use for the photography of the spectrum showed that the maximum light action was produced by the blue and violet rays and that the effect persisted beyond the visible spectrum into the region which was termed the "ultra-violet." This effect has since been found to be true of all ordinary photographic emulsions which are practically insensitive to green, yellow, and red light having wavelengths longer than 500 μ. The spectral sensitivity of the eye, on the other hand, has its maximum in the yellow-green at a wavelength of about 580 μ, dropping off on either side to zero at values of approximately 400 μ in the violet and 700 μ in the red region of the spectrum. The result of this is that the colors which appear brightest to the eye, namely green, yellow, and orange, are rendered as if dark by the ordinary photographic plate or film, while the dark blues and violets are reproduced as if they were bright. This state of affairs causes a great distortion of tone values and obviously makes any process of natural color photography impossible with ordinary or non-color sensitized materials. This can be remedied only by making the spectral sensitivity of the photographic emulsion correspond to that of the eye or by making the emulsion sensitive to all colors and then using a light filter to hold back those colors to which it is comparatively more sensitive than the eye.

As early as 1873 Vogel discovered that sensitivity to the longer wavelengths could be conferred by treatment of the photographic emulsion with certain dyes such as Eosine and Erythrosine which sensitized for the green and yellow. Plates sensitized with these dyes were placed on the market with the ambitious titles of Isochromatic and Orthochromatic plates, although they gave far from correct color rendering, since they had no sensitivity to the red and orange and but little to the yellow portions of the spectrum.

At this stage of the science of color sensitizing, Cyanine was the only dye known which imparted red sensitivity to a photographic emulsion but this gave trouble with fog and poor keeping properties.

Between 1902 and 1904 the sensitizing properties of the isocyanine series of dyes was discovered and good sensitizers were obtained for red light having wavelengths as great as 650 μ. In 1906, Homolka discovered Pinacyanol, a carbocyanine which sensitizes for wavelengths up to 690 μ.

Panchromatic plates, sensitized with a mixture of

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ENGINEERING DIGEST

Condensations of outstanding articles in the leading trade and scientific journals, published by special permission.

Babbitt Bearings Spun and Diamond Cut

By Robert E. Bultman

Assistant Metallurgist, White Motor Company

From Metal Progress, *November, 1931*

Although many motor-car and machine parts are now successfully using ball- and roller-bearings, babbitt and bronze bearings are still favored for many tasks. By the use of a simple machine which spins molten babbitt by centrifugal force into connecting-rod bearings, production has been increased, has become more economical, and the finished bearing is a better product.

The machine responsible for the change in manufacture consists merely of a round disk or face-plate mounted on a horizontal revolving shaft. An old lathe head or grinding-wheel is suitable for the disk. This plate carries also a jig in order to hold the connecting rod in its exact center as it revolves, and a sheet metal shield is provided to catch spatters of the molten babbitt, when it is poured on the connecting rod. A small center opening is left in front of the shield for pouring the babbitt. A hand ladle with a long protruding lip is used for pouring.

Both halves of the connecting-rod are fitted together in order to pour the complete bearing. This assembly is quickly accomplished with bolts and temporary shims of thin cast iron, thus keeping the babbitt from forming a continuous circle around the revolving rod. The assembled rods are first dipped in a commercial muriatic flux and then in pure, virgin tin. In this process the steel of the rods comes nearly to the heat of molten tin, 550 degrees Fahrenheit, but cools about 50 degrees while surplus tin is being brushed away and the rod is being placed in the fixture on the spinning wheel.

Babbitt, meanwhile, has been waiting molten in adjacent pots, maintained at a constant temperature of 650 degrees. When the steel connecting rod, now coated with tin, is locked in place the front shield is snapped shut, and the power is turned on. As soon as the rod and disk are rotating at the proper high speed (645 r.p.m.) the operator pours a measured amount of babbitt into position within the rod. Power is then shut off, and when rotation has died away, the babbitt has solidified, and the rod and bearing can be removed.

Centrifugal force distributes the babbitt evenly in the proper channel, quickly producing the close-packed, smooth surface essential for resistance to wear. Since the babbitt is carefully measured before it is poured on the rotating rod, bearings of any size can be made. About twenty-three connecting rods can thus be assembled, tinned and babbitted on the machine in an hour by one man.

The bearing is roughly ground first, and then the finish, requisite for a high-grade bearing, is attained by a diamond tool on a special bearing machine revolving at great speed. If an ordinary tool is used, tool marks remain, but with the diamond instrument no residue of soft matrix, or dross metal, is left to coat the desired hard antimony-tin surface.

Babbitt metal specifications call for virgin metals of great purity according to the following analysis: Tin, 87.25 per cent minimum; copper, 5.5 to 6.0 per cent; antimony, 6.5 to 7.0 per cent; lead, 0.35 per cent maximum; iron and bismuth each 0.08 per cent maximum; arsenic 0.10 per cent maximum; and no aluminum or zinc. By this method and with this composition of babbitt, bearings have proved most satisfactory, easy to manufacture, and of great durability.

Spinning babbitt metal into bearings by centrifugal force

—*Metal Progress*

Intersection Design — A Primary Highway Problem in New Jersey

By C. S. Hill

Condensed from Engineering News-Record, *Issue of November 26, 1931*

Heavy Philadelphia-New York inter-city traffic and enormous pleasure travel to seashore resorts call for the numerous elaborate road-crossing structures now in use,

Engineering News-Record

- The clover-leaf type of road intersection designed to eliminate traffic delays at busy crossings.

under construction, or proposed in New Jersey. To cope with the sixty thousand vehicles per day on the main highways alone, the engineer has to overcome two difficulties: (1) to provide for the interchange of traffic between one route and another; and (2) to provide for the crossing of four streams of traffic.

The simplest and most economical type of crossing is the flared intersection, as illustrated by the Toms River intersection. Sufficient flaring, theoretically, would allow an increase in the normal capacity of each road through the intersection. The extra space formed by flaring or widening the corners allows left-turn traffic to wait in the center of the intersection for breaks in the oncoming traffic without blocking the straight traffic behind. With full traffic control by spacing and light, and with the additional advantage of extra right-of-way, it is believed that the flared intersection may approach the capacity of the four-leaf clover type. Primarily, of course, the flared intersection provides for the crossing of traffic streams with only secondary provision for traffic not passing through the intersection.

Distribution of traffic, on the other hand, is the essential function of the circle intersection. A notably perfect circle was constructed in 1926 near Camden, New Jersey. At this point six roads converge, each contributing traffic to the others but in varying amounts. The problem was to distribute traffic with the least possible crossing of other traffic, and this circle solves it. The essential characteristics of all such intersections are: all traffic movements are at one grade; the majority of turns are with the traffic current; islands at road entrances separate entering and departing currents.

The most nearly perfect device for passing two streams of traffic is the grade separation. By itself it has no means to interchange traffic, so that a supplementary circle or ramps are used. The clover-leaf design, used in numerous intersections and illustrated by the airplane view of the Woodbridge crossing, may be used with either restricted or extensive areas, depending on the cost of land and the volume of traffic. The features are notable. The four-leaf clover permits each main roadway to carry 100 per cent of its capacity through the intersection, instead of the 30 per cent allowed by the ordinary intersection. Each main roadway is divided by a center island extending beyond the ends of the ramp to prevent left turns. The left turn is accomplished by a three-quarter turn to the right in the form of a loop beyond the grade separation. This loop, or reverse turn, is an unnatural turn (confusing to one's sense of direction). This confusion was anticipated, and numerous signs were installed to direct traffic. While there are no direct crossings at grade, there are two crossings at grade for each line of loop traffic, or four crossings altogether. Since these crossings, similar to those on a traffic circle, are accomplished in some distance of travel and with the flow of traffic, no difficulty is experienced.

Allied to the clover leaves, but of distinct type in the way they handle traffic, are such intersections as the one at Hasbrouck Heights. Left turns are made by a direct turn without cross traffic rather than by a reverse turn, this excellent effect being made possible by the complete absence of traffic interchange with one of the routes, a local phenomenon.

Of general principles dealing with intersections, the first is set down as law that each traffic intersection is a separate problem requiring an individual solution. The second principle is that present and future traffic should be capably analyzed and visualized, while the third holds that the plan or design should express the distinct purposes of the conveyors of traffic.

As supplementary principles, there may be mentioned:

1. Extra leeway for maneuvering should be provided at the point of meeting of traffic streams.

2. All turns should be arranged in the direction of traffic.

3. The physical lay-out should tend to induce proper traffic direction. Islands and local widenings are such features.

4. Signs should plainly indicate the proper traffic movements and the intersection should be clearly lighted so that these movements may not be hampered by poor visibility.

Better Engines For Navy Planes

By Commander C. A. Pownall, U. S. N.

Condensed from Scientific American, *December, 1931*

American aviation engine development is a subject which deservedly is receiving more consideration daily from the American public. This fact was clearly

emphasized during the last Congress when a special appropriation of $220,000 was allotted to the Navy to be spent specifically for high-speed development of naval aircraft.

The Navy's operating problem is peculiar to the Navy, for the simple but basic reason that the majority of its planes base on board ship and operate over the sea. Absolute reliability of equipment is of the first importance in this service. The daily operating routine on board the carriers *Saratoga* and *Lexington*, in which squadrons of planes take off from the carrier decks, perform their allotted battle tactics against distant planes and ships, and upon completion return and alight on board, bespeaks of itself a standard of engineering reliability and perfection that one scarcely appreciates, so commonplace has it become.

It is interesting to note the advance in airplane engine performance which has accompanied this improvement in reliability. A few years ago, a Navy service engine of a given piston displacement was rated to develop 350 horsepower at 1800 revolutions per minute. Today the same basic engine is capable of 500 horsepower at 2200 revolutions per minute, with a greater degree of reliability than existed in the 350-horsepower engine. It can be said with a fair degree of accuracy that for a given piston displacement, the power output has been increased some forty percent in ten years.

Now, both the automobile and the airplane industries have maintained a rather conservative engine development policy. The accepted service engine still operates on the old basic conventional Otto four-stroke cycle. Mechanical details have seen great improvement, but today the conventional automobile and airplane power plant is approaching the limitations of the basic type.

When we consider development, there are two courses to pursue — *normal engineering improvement* and *scientific research*. Normal engineering improvement is carried out continually by the airplane industry. For this purpose Congress annually appropriates to the Navy about $2,000,000, of which approximately one-fourth is usually allocated specifically for power plant improvement.

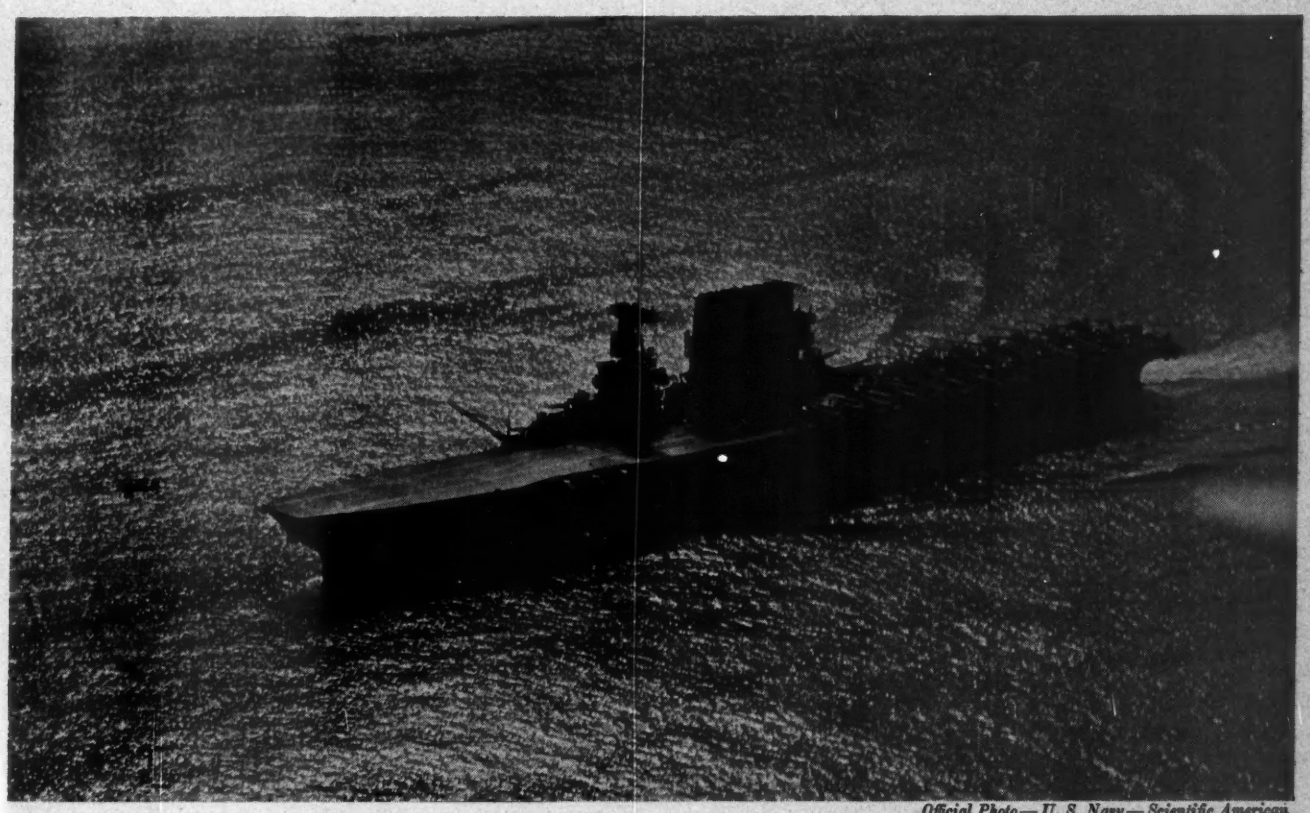
Neither the aviation industry nor the Navy has enjoyed the privilege of engaging directly in scientific research — the development of new and untried engineering ideas. There is no lack of ingenuity on the part of the engineering profession. Various reputable engineers throughout the world have formulated their ideas, but simply lack the capital with which to design, test and build. For example, Mr. Ricardo of Great Britain advocates the sleeve valve engine; others favor the revival of the two-cycle type, while still others advocate an engine specifically designed to lay within the wings. To demand of these men that they produce, on the first attempt, something the equal of or better than a perfected type, is an unreasonable requirement.

If Congress will entrust to the Navy sufficient funds to engage in progressive scientific research with the American aviation industry, the airplane will be made increasingly useful, not only to our national defense and to commerce, but to mankind in general.

Expansion Fits With Liquid Air

By chilling parts of machinery until they contract, thus allowing them to be inserted in their proper positions, a new liquid air process has partly replaced the old method of fitting by contraction. The term "expansion fit" by which the process is known is an accurate description of its operation. The pin or shaft is

(*Continued on page 238*)



Official Photo — U. S. Navy — Scientific American

One of the United States Navy's airplane carriers, making air attack and observation possible far out at sea.

The TECH ENGINEERING NEWS

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EDITORIALS

The New Board

With this issue, the Managing Board of Volume XII retires from office and hands over the affairs of the magazine for the coming year to the new Board of Volume XIII.

During the past year we have attempted to serve the student body of M. I. T. as best we could, and in the manner which we believed to be best. That we have fallen short of the goal which we should like to have attained is undoubtedly true. However, if we have in any small way contributed to the publication's growth and improvement we shall feel that the time and effort expended on it have not been in vain. Some changes, additions, and omissions have been made, all with a view to increasing the interest of the magazine to its readers, who are, after all, the final judges of the magazine's worth.

The Managing Board of Volume XIII will be Wilber B. Huston '33, General Manager; Donald G. Fink '33, Editor-in-Chief; Charles E. Buchanan '33, Business Manager; and Charles E. Fulkerson '33, Publication Manager, on the Senior Board. Comprising the Junior Board will be Edmund D. Lucas '34 and Joseph L. Seligman '34, Associate Editors; Frank M. Hartz '34, Treasurer; Robert E. Ebenbach '34, Circulation Manager; Charles T. Stewart '34, Managing Editor; and Walter F. Read '34, Advertising Manager.

To this new Board the outgoing Managing Board of Volume XII wishes every success.

Conceit

Almost any M. I. T. student will assure you in loud, confident tones that Technology is the greatest engineering school in the country, if not in the world, and that just getting through is a feather in anyone's cap, showing that the recipient of a degree is of the stuff of which engineers are made.

All of this may or may not be true. The point is that the average Tech undergraduate is very conceited about his school and is likely to mar rather than to add to Technology's reputation as a high-class technical institute by his attitude. It is a fine thing to be proud of one's school, but it is something very different to brag about it.

Technology has arrived at its present position by earnest, conscientious, hard work, and has let its results in the shape of leading engineers and scientists speak for themselves. If it is to maintain its present position of eminence, its products must continue to be leaders in their respective fields.

A quiet pride on the part of Tech students in their school, coupled with the determination to deserve the name of Technology graduate, will do more to keep Technology among the leaders than any amount of mere idle boasting.

Architecture and Civilization

Since the dawn of civilization, as we choose to call it, man's place of abode has had a marked influence on

his character, habits, and development. The cave-man, shivering beside his smoky blaze, covering the walls with crude frescoes, reacted no more strikingly to his environment than the modern penthouse dweller, thirty stories above the street, luxuriously stretching his toes before a wood-fire in a house already warmed by central heating. From the classic arcades of Greece to the barricaded castles of the Middle Ages, from the prim colonial mansions of the early republic to the nineteenth-century atrocities in brownstone and red brick, no single generation has failed to influence and at the same time be influenced by the prevailing style of architecture.

The architect, therefore, is a person upon whom rests a tremendous responsibility. Whether he will or no, his work will bear a direct relation to the advance of culture. The tendency of the modern design in America seems deliberately in the direction of sterility. With reproductions of country houses from England, France, Spain, Italy, and the other foreign countries, our architecture appears, according to distinguished critics, doomed to ever weaker plagiarism.

The healthy advance to counteract this spinelessness seems to be indicated in the progress in the architecture of skyscrapers. From merely being tremendous, soulless towers of steel and concrete, the newer giants have taken on a unique and pleasing effect. The silvery charm of the Chrysler Building, the massive splendor of the Empire State presage even greater achievements in the future. As a noted architect has suggested, the buildings of 1981 may well tower two or more thousand feet in the air. These super-skyscrapers will be little cities in themselves with conveniences for health, recreation, transportation, and industry hard to imagine. With such castles of the air already proposed the architect must assuredly leave his parrot-like weaknesses behind, and prepare to work with the brilliant new materials which science has prepared for him.

Vocabulary

In the article, "Human Engineering," appearing in this issue, the striking fact that all major executives possess a very wide vocabulary is brought out. Men who have the ability to direct and control large enterprises, it seems, have also the power to analyze their reading and to differentiate exact shades of meanings between words. To this extent, the possession of a wide vocabulary indicates a keen power of perception, the ability to pick out the essentials of a problem and to separate those things which ring true from those which are false.

Careful, painstaking reading of worthwhile literature should help to develop anyone's powers of perception. The examination of words in relation to the content of the sentence should go far toward building up a feeling for exact and precise meanings, not only of words, but of the parts of a problem of engineering, business, or executive character.

That reading of this sort also broadens anyone's point of view is also axiomatic. Technical students tend to become too one-sided from the very concentration upon one field demanded by their studies, and usually consider literature as extraneous and of little practical use in their work. Apparently careful reading of good literature helps to build up that habit of clear thinking and precise analysis which is an essential part of an engineer's mental equipment.

CHARLES ROBERT DARWIN

1809–1882

Darwin's work crystallized public acceptance of the evolutionary doctrine. He was amply endowed both by heredity and environment, but his education was a succession of failures. Although at the University of Edinburgh he became deeply interested in biology, he was later sent to Cambridge to study for the ministry. His clerical career gradually died a natural death and the voyage which Darwin took as naturalist on *H. M. S. Beagle* made his real career. This trip to the coasts and waters of South America, Africa and Australia, gave him the only intensive scientific training he ever received. His theory of evolution was born on the voyage and was brought into precise formulation on his return to England. It formed itself in his mind as a fresh conception, and not at all as an amendment or extension of older theories, such as Lamarck's. He came to doubt separate creation and to suppose, after making many observations during the voyage, that species have arisen through modification of existing species.

The two basic ideas in Darwin's law of natural selection are variation and the struggle for existence. He showed that the selective action exercised by the struggle for existence is the mechanism of the evolution of species. Bold enough to conceive the theory, he was not bold enough to make it public, waiting twenty years before publication of his "Origin of Species." This work contained a statement of the scientific evidence in favor of evolution, it explained the theory of natural selection, and it contained numerous facts interpreted to support the theory of evolution through natural selection. It was a tremendous success, but it started a storm of controversy which for its fury was and is unprecedented in the history of science.

LOUIS PASTEUR

1822–1895

Pasteur exemplified Lavoisier's ideal of science as the benefactor of humanity. His early work on the optical behavior of crystals led him to the question of fermentation and then to the germ theory of disease. While teaching at Lille, he was consulted by local brewers, who were having trouble with their fermentations. He soon showed them how to watch and control fermentation, and proved that a specific ferment created a specific product regardless of the fermentable material. The question of the origin of the micro-organisms that caused fermentation brought him into a long battle with Pouchet, Joly, and Musset over spontaneous generation. In a famous experiment, the apparatus for which was suggested to him by Professor Balard, the discoverer of bromine, Pasteur finally proved that no germs are produced without previous living germs.

The germ theory in animal diseases developed when, after his work on silk worm diseases and on the diseases of beer, he studied anthrax and proved that it was caused by a microbe. Antiseptic surgery as inaugurated by Lister was an application of Pasteur's ideas. Studies of temperature effects upon germs led to the pasteurization of milk and the development of the technique of transforming disease germs into agencies for immunization. He soon developed an anthrax vaccine, a weakened form of germ culture which could be used to produce immunity from anthrax. His career was closed with the discovery of a treatment for rabies and with the development of an antitoxin serum for diphtheria, perfected by some of his associates at the Pasteur Institute. "Laboremus — let us work!" was his life's motto.

Editor's Note — These two biographical sketches complete the series which has appeared in Volume XII during the last year. The ten great scientists whose names appear on the four pylons of the Great Court at Technology were presented to the men who walk beneath their memorials every day. Dr. Swann wrote a full-length article on Michael Faraday for the June issue to complete the series.

ELECTRIC HORSE

(*Continued from page 229*)

wheels by the amount of by-passed current. This feature increases locomotive efficiency 16.6 per cent.

The Cleveland Terminal in 1930 emphasized a new angle to railway electrification — that of air rights. The railroads had very valuable rights of way through the heart of the city which, when the lines were electrified and run in a tunnel under ground, could be leased out, bringing in much revenue. This sale of air rights became a most important factor in the financing of

Installing the huge oil-electric motor in the car.

Grand Central Terminal in New York, and is of growing importance. The Cleveland Terminal is electrified for only 17 miles of route with 3000 volts D.C. The Delaware, Lackawanna, and Western also has 3000 volts D.C. for 158 miles. The Reading Line uses the prevalent power of 11,000 volts single phase for 161 miles.

The Pennsylvania Line has the most extensive plan as yet devised for railway electrification, intending ultimately to connect New York and Washington by electrified road, the plan being based on broad economies to be derived from the use of electricity rather than steam in the very dense traffic conditions obtained in this run. Eleven thousand volts single phase power is used to connect with the New Haven Road. Some 450 miles of a proposed 1300 miles have been built. The Pennsylvania has two electric locomotives which can pull trains at 90 miles per hour, and which have the highest power per driving axle in the world — 1250 h.p. continuously.

The 4500 miles of electrified lines now in existence were built on the understanding that only under certain conditions are direct operating economies sufficient to affect the added capital charges and incidental expenses. It is much too early to prophesy any large replacement of the steam locomotive in regular service by the electric, but the way in which the newcomer is strengthening its position, increasing in size, and getting experience in arduous service, indicates that sooner or later it may cut an important figure in real railroading.

USES OF CATALYSIS

(*Continued from page 228*)

Sulphuric and Nitric Acids

Sulphuric and nitric acids are very important compounds. These acids are used directly or indirectly in the manufacture of a host of products, including fertilizers, glass, dyes, textiles, soaps, paper, inks, storage batteries, leather, food products, celluloid, lacquers, petroleum distillates, explosives, photographic films, and other materials too numerous to mention. Improvements in methods for the preparation of these acids receive much attention.

The contact process for the manufacture of sulphuric acid involves the use of a platinum catalyst. On account of the high cost of this metal, many attempts have been made to find a substitute for it. Recently these efforts were successful, and efficient vanadium catalysts are now used to a considerable extent.

Synthetic ammonia is rapidly becoming the source of nearly all fixed-nitrogen compounds, and it is now the primary raw material from which nitric acid is made all over the world. Since 1920 it appeared certain that nitric acid from ammonia would supplant that from Chilean nitrate in the United States. Improvements in the process for the oxidation of ammonia to nitric acid recently described involve the use of large, highly efficient units in which the reaction is carried out under high pressure and in the presence of a catalyst consisting of four-layer gauze cylinders of a new platinum-rhodium alloy.

Advantages of the new high pressure process over the atmospheric pressure oxidation method are said to be a low initial investment in the plant, a large increase in the concentration of the nitric acid obtained, high yields, and a decrease in the cost of catalyst.

New Syntheses of Organic Compounds

Methyl alcohol is used commercially as a solvent for shellac, in making varnish, in the preparation of aniline dyes and formaldehyde, and for other purposes. Ethyl alcohol is employed in pharmacy as a solvent, and in the manufacture of chloroform, iodoform, ether, collodion, dyes, perfumery, varnish and many other products. Esters derived from ethyl, butyl and amyl alcohols are constituents of nitrocellulose lacquers. New methods for the synthesis of important alcohols have been recently developed.

One of the greatest triumphs of modern industrial organic chemistry is the preparation of methyl alcohol (methanol) from carbon monoxide and hydrogen at a high pressure and in the presence of a catalyst composed of a mixture of metallic oxides. Synthetic methanol is replacing wood alcohol, as it can be made at a price to compete with the latter and is obtained free from undesirable impurities. Isopropyl, secondary butyl and tertiary butyl alcohols are now produced on an industrial scale by the catalytic hydration of unsaturated hydrocarbons formed in the cracking of petroleum. A number of primary and secondary amyl alcohols are manufactured by the catalytic hydrolysis of amyl chlorides obtained from the pentanes isolated from natural gas. In 1930 a substantial amount of synthetic ethyl alcohol (ethanol) was produced by the catalytic hydration of ethylene.

Large amounts of phenol are used in the manufacture of Bakelite resins, dyes and synthetic drugs. Until the last few years phenol was obtained by the distillation of coal tar and from benzenesulphonic acid. Phenol is now made commercially by the hydrolysis of chlorobenzene with sodium hydroxide solution under pressure and in the presence of a copper catalyst. The production cost in this new process is so low that synthetic phenol can be exported to Europe. Aniline is manufactured by a recently developed process which involves the treatment of chlorobenzene with water and ammonia at a high temperature and pressure, with the use of cuprous chloride as a catalyst.

The recent developments described in this paper are representatives of a long series of new catalytic processes which are revolutionizing chemical industries.

PHOTOGRAPHY

(*Continued from page 230*)

Pinacyanol and a green sensitizer, Pinachrome, and sensitive to all colors of the visible spectrum, were then put on the market by Wratten and Wainwright in England. These materials still had an excessive sensitivity for the violet, but in conjunction with a yellow filter (K3) which removed a portion of the shorter wavelengths, they gave very good orthochromatic tone rendering. Pinacyanol retained its place as the important sensitizer for panchromatic materials up until 1930 so that although there were many improvements in the speed, contrast, stability, and many other properties of the emulsions, the spectral sensitivity curve remained practically unchanged.

American research laboratories undertook an extensive investigation of the preparation of sensitizing dyes with the result that improvements in panchromatic plates and films were made from time to time and

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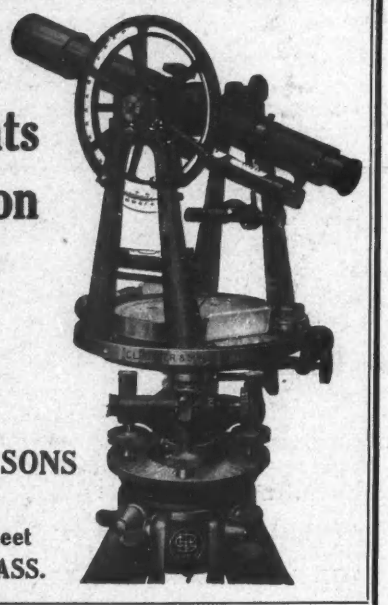
finally, in 1930, the discovery of entirely new sensitizers made it possible to introduce new materials of far greater general speed and sensitiveness to color than anything previously known. The new materials are grouped in orthopanchromatic and hyperpanchromatic classes. The first of these gives a sensitivity curve throughout the spectrum very closely resembling that of the eye except for the excess in the blue and violet. Plates or films sensitized in this way and used with the proper filter will give correct brightness values throughout the spectrum. The second gives sensitiveness concentrated towards the red end of the spectrum and has the property, in addition, of giving the highest possible total sensitiveness to the emulsion. A representative of this class is the new motion picture film which has been so valuable because of its tremendously increased sensitivity, particularly to artificial light. Its use has greatly increased the versatility of the camera under difficult conditions of light, and has greatly reduced the amount of light required on the usual set.

The spectrograms for these various materials are reproduced in the figure, in which the wavelengths are indicated along the bottom of the scale, and the sensitivity is represented by the height of the light area. These were made by daylight but if artificial light which is very rich in red and deficient in blue had been used, they would all have indicated relatively greater sensitivity for the longer wavelengths. The first spectrogram is for an ordinary or non-sensitized emulsion. The next is for an orthochromatic or Erythrosine sensitized emulsion, and the third is for the old type panchromatic or Pinacyanol sensitized emulsion, while the last two are for the new types of panchromatic materials.

In addition to the sensitizers for the visible spectrum, a number of dyes have been found which sensitize for the extreme red and the infra-red. Pictures taken by infra-red light have a rather remarkable appearance. The blue sky reflects very little light of long wavelengths and consequently is almost black in the photographs. Chlorophyll, on the other hand, has no absorption for the extreme red, so that grass and leaves photograph as the highest lights of the landscape. Because of the intense local lighting and the blackness of the sky these infra-red pictures resemble night photographs. In fact, Kryptocyanine film has been used in motion picture work to obtain photographs by sunlight which look as if they were taken at night, with an enormous saving for the night lighting which would otherwise have been necessary.

In addition to these bizarre effects, however, photography by long wavelengths has the great advantage of giving a very high degree of penetration through haze. The atmosphere scatters a considerable amount of blue light thus causing the blue haze which appears to veil distant objects. By using a filter to cut out this scattered light and film sensitive to the long wavelengths, clear pictures can be taken at very great distances. This is the method used by Captain A. W. Stevens in obtaining his well-known long distance photographs from aeroplanes. The most notable of these, a photograph of the Andes range taken at a distance of 310 miles, shows the haze over the Pampas silhouetted against the mountains in such a way as to demonstrate very clearly the curvature of the earth. The limit of visibility for the eye was considerably less than half the distance at which the clear photograph was made.

Standard Instruments of Precision



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HUMAN ENGINEERING

(*Continued from page 225*)

first experiments were carried out at Stevens Institute of Technology. Massachusetts Institute of Technology freshmen registered for the course in Engineering and Business Administration are now required to take the tests in an endeavor to ascertain whether they are suited for that work or would do better in a more purely engineering course. One of the most important tests given the freshmen is the vocabulary test. Executives in general, no matter what work they may be pursuing, rank highest in this test. To be a successful executive, the subject should do very well in this test, but he may rank high and not make a good executive.

ENGINEERING DIGEST

(*Continued from page 233*)

machined to a size slightly larger than the hole in which it is to be fitted. It is then immersed in liquid air. The resultant cooling produces a contraction in diameter which allows the part to slide very easily into the hole prepared for it. On returning to room temperature it expands to its previous diameter, thus gripping the outer part with considerable force. While the price of liquid air indicates certain limitations to its use, there are numerous fits which can be made more easily and more economically by this process than by any other, and some which can be made in this way only.

An Airplane Catapult on Land

Raising a nine-ton airplane into the air within three seconds, after a run of 100 feet, a land-type catapult was successfully tested recently at the Royal Aircraft Establishment, Farnborough, England. In opposition to the marine catapult, traction is used in the new type, rather than propulsion. The motive power is provided by a compressed-air engine geared to a drum. A steel cable runs from quick-release hooks on the bottom of the plane's fuselage through a pulley anchored to the ground at the end of the short runway, and onto the drum. Turning the drum gives the plane a high velocity toward the pulley. When the pulley is approached, a retarding mechanism releases the cable hooks, permitting the plane, which has acquired sufficient momentum to rise under its own power. The entire operation requires approximately three seconds.

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